conſequently the angles *AEB* and *CFD* are equal. That is, the angle ſubtended by the diſtance of the centers of the ſegments from the diſtance of the focus of parallel rays is equal to the angle ſubtended by the diſtance between the objects *A* and *B* from the end of the teleſcope.

XXVIII. *A Letter to Sir* Peter Thompſon, *Knt. F.R.S. containing Experiments on the* Copper Springs *in* Wicklow *in* Ireland, *and Obſervations thereon, by* John Bond, *M.D.*

SIR,

Read May 10, 1753.

YOU may remember I had the honour of ſpending an evening with you in June laſt, and happen'd to mention a ſpring in the county of Wicklow in Ireland, which was ſuppoſed to have the ſurpriſing quality of changing iron into copper. But your conſtant love of truth, and ſtrong averſion to vulgar errors, made you doubt the fact, which, at that time, I could only affirm on the report, which prevailed among the curious in that country. You then propoſed ſeveral judicious queries, and ſeemed deſirous of being further informed concerning it, which raiſed my curioſity to take the firſt opportunity of inquiring more particularly into the foundation of that marvellous account.

Having ſoon afterwards occaſion to go to Dublin, I went to the ſpring, which is from thence about thirty-eight miles, and made ſeveral experiments on the

The Royal Society is collaborating with JSTOR to digitize, preserve, and extend access to *Philosophical Transactions (1683-1775).* www.jstor.org

the water; the reſult of which I beg leave to preſent you with, hoping it may afford you ſome ſatisfaction in explaining that proceſs, of which you ſo juſtly doubted the account given by ſome credulous authors, who miſtook it for a real tranſmutation; a ridiculous doctrine, which deſtroys the eſſential qualities of bodies, which were impreſſed by the Great Creator on all material ſubſtances, in order to diſtinguiſh them from each other, and therefore are intranſmutable.

As the hiſtory of this diſcovery has already been accurately related, in ſeveral papers read before the Royal Society, of which you have the honour of being a worthy member, I ſhall endeavour to avoid repetition, and confine myſelf to the chemical analyſis of the water, which, I am told, has been hitherto omitted.

This water flows from a rich copper mine, and is of a ſharp acid taſte, and light-blue colour. It is received and collected in pits, wherein iron bars are put, which, after lying in the water about three months, are intirely conſumed, and at the bottom of the pits, a quantity of copper, greater than that of the iron is found, in the form of coarſe ſand. This fact is confirmed by profitable experiments, often repeated ſince the diſcovery, the honour of which is due to Mr. Matthew Johnſton, a worthy old gentleman, and one of the proprietors of the mine, who firſt propoſed this method of collecting the copper.

As this effect is certainly produced by ſome active principle in the water, I ſhall firſt inquire, what this principle is, and mention particularly the experiments, which I made with this view, that you may the better judge of the inferences deduced from them.

Experiment 1.

Into ſome of this water, taken out of the ſtream above the pits where the iron bars are placed, I pour'd a ſolution of an alkaline ſalt, which raiſed a ſtrong efferveſcence, and precipitated a large quantity of a dark brown ſubſtance.

Corollary. This experiment ſhew'd, that the water contain'd a ſtrong acid, with a ſolution of the ſubſtance precipitated.

Experiment 2.

I put ſome aqua-fortis, or ſpirit of nitre, into ſome water taken out of the ſame place; and obſerved, that the ſtrong acid immediately deſtroy'd the blue colour.

Corollary. From this experiment we may conclude, that the ſubſtance, which was precipitated by the alkali in the firſt experiment, was ſo perfectly diſſolved by the acid ſpirit in the ſecond, as to tranſmit all the rays of light.

Experiment 3.

Some ſmall iron nails put into this water were in four minutes ſo cloſely cover'd with ſome ſubſtance of a copper colour, that, with a magnifier of half an inch focus, I could not diſcern the iron through it. In that time the nails gained four grains. The water had the ſame effect on ſilver and tin, but not on gold.

Corollary. The colour and increaſe of weight were owing to the adheſion of the particles of the matter diſſolved in the water by an acid, that could not penetrate gold.

Experiment 4.

In order to determine the quantity and quality of the matter in the water, I put two drachms of ſmall iron nails into three ounces of it, and let them ſtand twenty-four hours; then examined, and found the ſurface of the water cover'd with a thick ſcum, like that of a chalybeat Spa. It loſt the blue colour, and ſharp vitriolic taſte. It was quite tranſparent, and at the bottom there was a quantity of a brown ponderous powder, which, when dried, weigh'd 14 grains. This powder, melted without any flux, produced 12 grains of pure copper. The nails loſt 8 grains in the water, and were, in ſeveral places, cover'd with a ſolid lamina of pure copper. The water, in which the nails lay, after being filtrated and evaporated, afforded a green vitriol, which in every reſpect reſembled *ſal Martis*, and produced the ſame effects, when diſſolved, and mix'd with any aſtringent tincture.

Experiment 5.

From the ſpring-water treated in the ſame manner, I obtain'd a blue vitriol, the baſis of which is copper.

From all theſe experiments it appears, that a mineral acid is the active quality in this water; which being diffuſed thro' the copper ore, unites itſelf with that metal, and forms a vitriol, which is diſſolved by the water, and remains ſuſpended in it, till it meets with iron in the pits, by which this acid is more ſtrongly attracted than by the copper, therefore ſore it quits the copper, corrodes the iron, and changes it into a vitriol, which is again diſſolv'd, and carried off in the ſtream continually flowing from the pits; whilſt the copper, deſerted by the acid, falls, by its ſpecific gravity, to the bottom of the pits.

By this account it is evident, that this admirable proceſs is a ſimple precipitation of the copper, by means of the iron. Hence it has been improperly called a tranſmutation of iron into copper. But, leſt any difficulty ſhould ſtill remain, concerning the conſumption of the large quantities of iron put into the pits, I ſhall add the following obſervations, to ſhew, that it is diſſolved and carried off in the water.

Obſervation 1. The water in the pits is cover'd with a thick ſcum, occaſion'd by the air-bubbles conſtantly riſing, and burſting on the ſurface; which is an evident ſign of the ſolution of the iron.

Obſ. 2. The iron is gradually conſum'd in the pits, and abounds with irregular depreſſions, like old iron: a ſtrong ſymptom of its being corroded by an acid.

Obſ. 3. The chanel of the ſtream running from the pits is furr'd with red oker, which, after being roaſted in a ſtrong fire, was attracted by the magnet. As this oker is only found in the ſtream below the pits, it appears to be part of the iron diſſolv'd in the water.

Obſ. 4. The quantity of copper found in the pits, after the iron diſappears, is generally greater than that of the iron when firſt put in: for the proprietors aſſured me, that ſometimes a ton of iron will produce, or rather precipitate, a ton and half of copper.

This fact alone would be ſufficient to prove, that the iron is not converted into copper; ſince, according to Sir Iſaac Newton's table, the ſpecific gravity of copper is to that of iron as 9000 to 7645.

When I was at this ſpring in Auguſt laſt, it ran at the rate of 12 ounces every ſecond; and by putting iron into the water of the ſtream running from the pits, I found, that every ounce contained three grains of copper. Hence by calculation it appears, that 129600 grains of copper are carried off every minute, and conſequently 124100 pounds Troy weight in a year; ſuppoſing the quantity and quality of the water to continue the ſame.

Hence we may eaſily account for the death of the fiſh, and other phænomena in the river, which receives this vitriolic ſtream.

In a hot ſunny day, when the water is exhaled, the heaps of mold, raiſed out of the ore-pits, are cover'd with a vitriolic efflořeſcence: hence, in rainy weather, the water appears like a ſtrong ſolution of verdegriſe.

Whoever is deſirous to imitate the proceſs carried on in theſe pits, may readily gratify his curioſity, by putting pieces of iron into ſtrong ſolutions of vitriol.

It is a common experiment, to tinge poliſh'd iron by rubbing it with Roman vitriol; which depends on the cauſe before-mention'd; *viz.* the acid in the vitriol penetrates the iron, and leaves the copper on the ſurface. This experiment is alſo taken notice of by that excellent chemiſt, and celebrated philoſopher, Mr. Boyle, who calls it a *ſympathetic precipitation*, in his *Eſſay on ſpecific Medicines.*

As ſoon as the attraction between the copper and the acid ceaſes, the mutual attraction between the minute particles of the metal prevails, ſo as to form large ſolid maſſes at the bottom of the pits, nineteen twentieths of which are pure copper. Theſe ſolid maſſes are partly occaſion'd by the preſſure of the incumbent heap of granulated copper, conſtantly increaſing.

Hence we ſee, that the art of eſſaying, or ſeparating metals from their ores, chiefly conſiſts in evaporating an acid, which prevents the mutual attraction of the metallic particles: for when the acid is driven off by the violence of fire, the particles fall into their proper ſphere of attraction, and aſſume a ſolid form.

From what has been offer'd on the theory of this admirable proceſs, ſeveral practical hints may be taken to render ſuch ſprings more profitable; and perhaps an eaſier method may be diſcover'd of ſeparating copper from its ore, by precipitation, than by calcination. But ſuch improvements I refer to thoſe more converſant in the practice of metallurgy.

Having, I hope, given a ſatisfactory account of the effects of this water on iron, and proved, that it is owing to a ſtrong mineral acid, which it contains, I ſhould next inquire into the ſource of this acid; but am anticipated in that conjectural reſearch by many inquiſitive gentlemen, who have penetrated deeper into the bowels of the earth, and diſcover'd, or rather taken for granted, a vague acid, which, they ſay, is diffuſed thro' the whole mineral kingdom, and being united with different mineral ſubſtances, forms vitriols of different kinds. This hypotheſis appears the more probable,

probable, ſince it is allow'd by modern chemiſts, that all acid ſpirits, tho' extracted from different minerals, produce the ſame effects, and conſequently are of the ſame nature, the ſpirit of ſea ſalt only excepted, which alone diſſolves gold.

Since vaſt quantities of ſulphur are found in this mine, mix'd with the copper-ore, it is probable, that the acid of the ſulphur is attracted by the copper, and formed into a vitriol, which is afterwards diſſolved by the water.

A farther inquiry into the origin of this acid, I leave to thoſe curious gentlemen, who have ſolv'd the phænomena of volcano's, earthquakes, hot-ſprings, *&c.* from its effects.

The ingenious Dr. Robinſon has lately illuſtrated this doctrine of acids *, by proving, that an acid and light are the ſame thing: for he infers, from Sir Iſaac Newton's philoſophy, that whatever attracts, or is much attracted, is light: therefore an acid is light.

This ſpring perhaps is as remarkable for its medicinal as its metallic qualities. Tho' phyſicians generally reckon copper taken internally poiſonous, yet the miners and other people drink this water frequently, without any ill conſequences. It purges and vomits ſeverely, and is become their ſpecific in ſeveral diſeaſes, particularly in cutaneous eruptions, ariſing either from an alkaline acrimony in the blood, which ſtimulates the ſenſible extremities of the cutaneous arteries, and occaſions a puſtule, or from the irritation of inſects lodg'd in the ſkin; both which cauſes may be removed

---

* See his Eſſay on the Operations of Medicines.

removed by the ſtrong acid in this water. It is an excellent detergent for ſcorbutic ulcers, as Hoffman juſtly obſerves. It has already perform'd ſeveral remarkable cures of this kind. I have often recommended it in ſuch caſes with ſucceſs, join'd with proper internal medicines; for I am no friend to ſpecifics.

How far the ſucceſs of practice of the miners, who drink it frequently, may be depended on, longer experience muſt determine. Certainly, a great allowance muſt be made for the ſtrength of their conſtitutions, and the inſenſibility of their nerves, conſtantly expoſed to the noxious ſteams of damp pits. I never ventur'd to preſcribe it internally; and as the *materia medica* affords vomits and purges of a more innocent kind, I think it in that reſpect unneceſſary. I have reaſon to imagine, from the effects, which this water had on ſome earth-worms, that it is a very powerful anthelminthic, if cautiouſly given.

Some freſh filings of iron, put in this water, ſoon precipitate all the copper, and make it a ſtrong and agreeable chalybeat. Hence it may be us'd as a ſubſtitute to Spa-water, whoſe virtue depends on the iron. Some prepared filings of iron remain'd eight days in this water; without producing the leaſt alteration. Hence it appears, that this medicine can have but a weak effect, if any at all, in abſorbing acids in the firſt paſſages.

Thus having communicated all, that at preſent occurr'd to me, relating to this ſpring; if theſe obſervations render the hiſtory of it more perfect, and in the leaſt contribute to gratify that laudable curioſity, which you always ſhew, in removing prejudices,

rectifying

rectifying miſtakes, and encouraging every branch of uſeful knowlege, I ſhall think my time well employ'd in this inquiry, which had its riſe from your inſtructive converſation. I am, with the higheſt reſpect,

SIR,

London, April 15, 1753.

Your moſt obedient, and
most humble ſervant,

John Bond.

XXIX. *A Letter from Dr.* Bevis *to Mr.* James Short, *F. R. S. concerning Mr.* Gaſcoigne's *Invention of the* Micrometer.

Dear Sir,

Read May 17, 1753.

ALTHOUGH Mr. Townley, in his letter to Dr. Croon, printed in the *Philoſophical Tranſactions*, Nº 25, p. 457, has ſufficiently made appear, that the invention of the micrometer was Mr. Gaſcoigne's, and that he applied it to meaſuring ſmall angles in the heavens, and for ſettling the moon's parallax, long before Meſſieurs Auzout and Picard thought of any ſuch matters; yet are the French aſtronomers at every turn for giving it to theſe their countrymen, without ſo much as once mentioning the name of Mr. Gaſcoigne.

No ſooner had the late Dr. Derham reſtor'd the application of teleſcopic ſights to quadrants to its true author Mr. Gaſcoigne, than M. de la Hire, who never made the doctor any reply on that head, took occaſion,